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Model-Dependent Sampling Versus Point-Poisson Sampling on a Colorado Timber Sale

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Estimates from point-Poisson and a model-dependent sampling procedure called pscX are compared with large sample estimates in a timber sale area. The pscX estimates are closer to the large sample estimates for both sawtimber volume in board feet and fuelwood volume in cubic meters. Similar results have been observed in other studies. The pscX procedure was more precise for fuelwood but less precise for sawtimber volume than the point-Poisson procedure.

Keywords: pscX sampling, fuelwood, sawtimber

This research supplements Schreuder et al. (1984), which contains the relevant literature on model-dependent sampling. In that article a model-dependent (MD) sampling procedure called pscX (purposive sampling from the cumulated X's) was compared to point-Poisson sampling; the methods only differed in tree selection for volume measurement. Interest was only in fuelwood (i.e., total bole wood biomass in cubic meters). The pscX and point-Poisson estimates yielded estimates of approximately equal precision. The pscX procedure (Schreuder 1984) takes advantage of the strong linear relationship between y (cubic or board foot volume) and x (= D^2H or diameter at breast height squared times total height). The procedure selects trees with X values close to the average X values in each of n classes,

$$C_i = \left[\frac{X_T}{n} \cdot (i-1),\ \frac{X_T}{n} \cdot i\right], \quad i = 1,\ldots,n$$

where X_T = population total for covariate x.

In actual practice X_T and the number of trees (N_i) in each of the classes (C_i) must be known in advance or are estimated from a preliminary sample.

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This note compares point-Poisson sampling with model-dependent sampling in which the complete sampling design for the latter is tailored to information needed for pscX sampling. Interest is in both fuelwood volume (trees less than 17.8 cm in d.b.h.) and sawtimber (trees larger than 17.8 cm in d.b.h.). Similar work is given in Wood et al. (1985) and Biggs et al. (1985). Wood and Schreuder (1986) discuss implementation of model-dependent procedures and Schreuder and Wood (1985) compare model-dependent and design-dependent procedures from a conceptual viewpoint.

Population

The population area sampled consisted of three small timber sale areas of 4.45 ha, 0.73 ha, and 4.65 ha, a total of 9.83 ha. A 40% shelterwood cut is planned on the 4.45-ha area. Trees to be cut were all marked prior to sampling. All trees are to be cut on the two other areas. The principal tree species is lodgepole pine, with some Douglas-fir and aspen mixed in. The two parameters of interest were total fuelwood volume (in cubic meters) for trees less than 17.8 cm d.b.h., and total sawtimber volume (in square meters) for trees larger than 17.8 cm. Tree species was ignored. Both live and dead trees were included.

Methods

A preliminary sample of 17 variable radius plots with a metric basal area factor (BAF) of 2.30 (10 in English units) was taken with relascope. Tree diameter in centimeters (D) and total height in meters (H) were measured on the trees on these plots. A total of 135 fuelwood and 121 sawtimber trees was measured. Based on this preliminary sample, X_T and N_i (i = 1,...,n) were estimated for the n classes in pscX sampling. Then for each of the n classes

$$\bar{X}_i = \hat{X}_T/nN_i$$

was computed. Those volume trees were selected for pscX sampling that first satisfied the condition that their visually estimated D^2H value was within 0.05 $\bar{X}_i$ (i = 1,...,n).

Based on the preliminary sample, grids of 35 and 122 plots were imposed on the population area (proportionally allocated to the three areas) for fuelwood and sawtimber. Forty-seven and 114 trees were to be Poisson-selected for fuelwood and sawtimber. At each point, visually determined height and diameter of each tree included in the 2.3 - point BAF plot sampled by a relascope were obtained. The visually determined height of each tree was compared to a random number from the uniform distribution between 1 and the sum of the estimated heights on the 35 and 122 points divided by the desired sample sizes for Poisson sampling (47 and 114 trees respectively). If the random number was less than or equal to the visually determined height, the tree was a sample tree. This was done separately for trees visually estimated to be less than (fuelwood) or larger than 17.8 cm (sawtimber)

On sample trees, necessary dendrometry measurements up the stem were taken to compute volume (basically the same measurements for fuelwood or sawtimber), measured diameter at breast height (D), and measured total height (H). These were taken with the relascope. To avoid bias in the visual estimates, the person estimating heights was kept unaware of the true height of sample trees. Points were sampled until at least 47 fuelwood and 114 sawtimber sample trees were selected. At least 35 and 122 points had to be sampled for fuelwood and sawtimber, respectively. In actuality, 38 and 122 plots were visited to get the respective 47 and 114 fuelwood and sawtimber sample trees.

Because it took about equal time to complete a MD-plot and a PP plot, the same number of plots (points) and sample trees was used for both methods. For the MD sampling, fixed area plots with radius of 6.8 m were used. At each plot the number of trees and visually estimated height (H_o) and diameter (D_o) of each tree in the plot were recorded. A tree was randomly selected in each plot for diameter and height measurement. A total of 47 fuelwood and 114 sawtimber trees were purposively selected. The first tree with D^2H-value within 5% of the selection D^2H-values from the preliminary sample was taken until the desired sample was achieved.

An additional sample of 118 sawtimber and 40 fuelwood plots from each of the 3 timber sale areas was selected proportional to area, in a manner similar to that described earlier for MD sampling. Volume measurements were taken on the smallest tree on each plot (to get the average D^2H for volume-measured trees closer to the population mean) for either fuelwood or sawtimber. Information from these plots was combined with information from the MD and PP samples, to create the large sample. With the large sample the same estimation approach was used to estimate total volume as was used in model-dependent sampling.

Results and Conclusions

The results (table 1) show that the model-dependent pscX estimates of total volume (either sawtimber or fuelwood) are closer to the corresponding large sample estimates than are the point-Poisson estimates. This was also observed in previous studies (Schreuder et al. 1984, Wood et al. 1985) for fuelwood volume. For fuelwood the pscX procedure is more precise than point-Poisson sampling. However, for the sawtimber volume in board feet, the point-Poisson procedure was more precise.

Table 1.—Estimated cubic meters and board foot volumes for sawtimber and fuelwood populations using three samples.

	Sawtimber volume (board feet)	Jackknife standard error	Fuelwood volume (cubic meters)	Jackknife standard error
Large sample	73,304	5.3%	27,149	5.0%
pscX sample	73,271	10.5%	26,590	12.2%
Point-Poisson sample	67,733	9.3%	31,285	14.3%

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